Innovative Research on Digital Teaching of Ink Painting for Preschool Children Driven by Computer Graphics Algorithms

Yihong Chen[1],*

[1] Quanzhou Preschool Education College, Quanzhou, Fujian, 362000, China

Corresponding authors: (e-mail: 15294580660@163.com).

Abstract The rapid development of digitalization in education is gradually changing the traditional teaching mode, especially in the field of art education, this transformation is more and more significant. This paper delves into the practical application of graphology algorithms in children's ink painting courses in higher teacher training colleges in an attempt to enhance students' artistic creation ability and teachers' teaching level through innovative digital teaching methods. This paper proposes an innovative teaching platform, which uses graphology algorithms to simulate the changes of ink strokes and ink colors in ink painting, and seeks to realistically reproduce the artistic effects of traditional ink painting in a digital environment. Through this approach, students are able to intuitively perceive and master the skills of ink painting creation in a virtual teaching environment, thus stimulating their learning interest and artistic expression. Empirical studies have shown that this teaching method based on digital means has not only achieved remarkable results in improving students' artistic expression, but also effectively enhanced their learning motivation. At the teacher level, the construction of the relevant training system has also been widely praised, and the teachers' professionalism and teaching ability have been significantly improved. The research in this paper not only provides strong support for the theory of digital transformation of education, but also guides the direction of modernization and reform of children's ink painting curriculum, which is of great significance in promoting the digital development of art education in China.

Index Terms education digitization, graphics algorithms, ink painting teaching, art education, teacher training

I.   Introduction

With the arrival of the digital era, the traditional education model is facing a major transformation, especially in the field of art education, this transformation is particularly obvious. Art education not only needs to cultivate students' artistic expression ability, but also needs to improve teachers' teaching level and informationization application ability. However, the teaching methods in traditional art education generally rely on teacher-disciple teaching, and students are faced with more abstract artistic skills and creative expression in the learning process, which is effective but has limitations for the changes in modern educational needs [1]-[3]. Especially in the teaching of ink painting, traditional teaching is often difficult to flexibly respond to the individual needs of students, and also fails to effectively use modern technology for teaching optimization.

Graphics algorithms, as one of the important technologies of computer graphics, provide a new development direction for art education, especially ink painting teaching, by virtue of its powerful image processing and visual effect simulation capabilities [4]. Ink painting, as one of the traditional Chinese arts, emphasizes the rhythm of ink and brush and the creation of artistic mood, and the graphics algorithms can simulate these artistic characteristics and provide students with a more intuitive and realistic experience of ink painting creation through digital means [5]. In addition, with the continuous advancement of education digitization, the enhancement of teachers' digital literacy has become an important direction of education reform, and the introduction of digital technology has an indispensable role in enhancing the teaching level of teachers and the artistic expression of students.

This study is dedicated to exploring the innovative application of graphology algorithms in the children's ink painting course for senior teachers, aiming at the construction of a digital teaching platform, which can not only enhance the students' artistic creation ability, but also provide teachers with effective teaching aids and promote the modernization and reform of art education.

The core idea of this study is to combine the graphology algorithm with the teaching of children's ink painting course for senior teachers to construct a set of innovative digital teaching methods. Firstly, based on the simulation and reproduction of the brush strokes, ink colors and layers of ink painting by the algorithm of graphics, the image processing technology in graphics is used to realize the digital presentation of the artistic

characteristics of ink painting. By developing a digital teaching platform, students can intuitively perceive and master the techniques of ink painting in a virtual environment, which enhances the fun and interactivity of learning.

Secondly, this study introduces an intelligent evaluation and instant feedback mechanism in teaching, so that teachers can understand students' learning progress in real time and provide personalized guidance, solving the problem of meticulous tutoring, which is difficult to achieve in traditional teaching. At the same time, the study also designs a teacher training system to improve teachers' digital teaching ability and art creation guidance ability.

Finally, the study will verify the promotion effect of this digital teaching method on students' artistic expression, creative interest and learning motivation through empirical analysis, providing new ideas and references for the application of digital teaching in art education.

II. Literature review

Before exploring the digital teaching innovation of children's ink painting course for senior teachers, its theoretical support needs to be analyzed in depth. The theory of digital education transformation lays the foundation for this study, which describes the role of information technology in promoting educational innovation, and emphasizes that the application of technology needs to reconfigure the teaching environment and optimize the allocation of resources [6], [7]. The theory of integration of pedagogical knowledge states that teachers should have the ability to integrate technology, subject content and pedagogical knowledge, and the development of this ability is crucial to the digital teaching of ink painting [8]-[10]. In the field of graphics algorithms, application theories based on digital image processing and computer vision provide technical methods for the digital processing of ink painting, including image segmentation, feature extraction and other algorithms that can simulate the brush strokes and ink color changes of ink painting [11]-[13]. Deep learning algorithms learn to extract artistic features through a large number of works, and the combination of constructivist learning theory and digital teaching tools creates a rich exploration environment for students [14].

The digital transformation of art education faces the problem of integration of tradition and modernity, which requires innovative teaching methods while maintaining the artistic essence of ink painting [15]. The "mood" and "ink" characteristics of ink painting teaching determine that the application of digital technology must follow the laws of artistic aesthetics, while research on the psychology of children's art education has shown that vivid visual presentation and interactive experience can help stimulate learning interest. The theory of teachers' digital literacy reveals the direction of teachers' professional development in the new era, which requires teachers to master the development of digital resources and instructional design skills. Based on these theories, digital teaching of ink painting needs to pay attention to controlling the cognitive load in the application of technology, avoiding the overuse of technology and affecting the artistic feeling.

The cognitive theory of multimedia learning provides important guidance for digital teaching of ink painting, which affects the presentation and organization of teaching content. Contextual learning theory emphasizes the authenticity of the learning environment, and technologies such as virtual reality are just able to simulate real art creation scenes. By integrating these theoretical foundations, we are able to construct a teaching system that maintains traditional characteristics while taking advantage of digital technology. In practice, the use of these theories needs to take into account the cognitive characteristics of children and the laws of artistic development, so that the application of technology can truly serve the achievement of teaching goals. The digital transformation of contemporary art education is not only an innovation of technical means, but also an innovation of educational concepts and methods, which needs to be cautiously promoted under the guidance of theories to ensure the improvement of teaching effects.

III. Research methodology

III. A. Literature research methodology

Based on the literature research conducted by China Knowledge Network and Wanfang Database, focusing on the research dynamics of ink painting teaching, education digitization and graphology algorithms in the past five years, a large amount of literature reveals the role of digital teaching method innovation in promoting the transformation of education. It is found that the application of graphology algorithms in the field of art education is mainly embodied in two levels, one of which is the image processing technology that realizes the precise recognition of the characteristics of traditional ink painting strokes, and the other is the visual presentation technology that reproduces the effect of the mood of ink paintings through digital modeling. In examining the practice of digital transformation of art education in higher education, Germany's "Digital Higher Education Innovation Scholarship" program provides us with valuable experience. It is worth noting that although some Chinese universities have made progress in the development of digital teaching tools, problems such as insufficient teacher training and imperfect resource sharing mechanisms still exist. Through in-depth analysis of

related studies, we note that the existing results focus excessively on the technical aspects, while the attention to the laws of art education and children's cognitive characteristics is obviously insufficient. To solve this problem, we need to explore the in-depth integration of graphic algorithms and ink painting teaching, and innovate teaching methods based on maintaining traditional artistic characteristics. Meanwhile, the improvement of teachers' digital literacy plays a key role in promoting the digital transformation of education. This prompts us to think about how to design appropriate training programs for teachers of higher education institutions in the application of digital technology, so as to provide theoretical support for subsequent practical research.

III. B. Questionnaire method

The questionnaire survey, as the main means of collecting primary data for this study, was designed to focus on the innovation of digital teaching of children's ink painting in higher education. Based on the analysis of the current situation and needs of the curriculum, we constructed a questionnaire structure covering three major dimensions: innovation of teaching strategies, utilization of teaching resources, and evaluation of teaching effectiveness. A total of 42 ink painting teachers and 386 students from five institutions of higher education were selected as respondents, and the questionnaire was rated on a five-point Likert scale, with values ranging from 1 (strongly disagree) to 5 (strongly agree). During the design process, we invited three experts in the field of pedagogy and two experts in art education to participate in the assessment of content validity, and the reliability coefficient derived from the combination of the pre-test data was 0.892, which fully demonstrated that the questionnaire possessed a high standard of reliability and validity. Through this approach, we hope to deeply analyze teachers' and students' perceptions and attitudes towards current digital teaching methods, and provide data support for teaching reform. The results of data analysis of teaching method innovation survey are shown in Table 1.

Table 1: Survey data on teaching method innovation

Investigation dimension	Means	STD	The proportion above the mean	The proportion below the mean
Digital tool application	4.12	0.89	56.5%	43.5%
Teaching content design	3.94	0.77	68.5%	31.5%
Interactive teaching mode	4.07	0.84	55.4%	44.6%
Innovation evaluation methods	3.84	0.77	68.5%	31.5%

Analysis of the questionnaire results shows that the use of digital tools in teaching is recognized by the majority of teachers, with more than half of them having a positive view of the role of graphological algorithms as an aid to teaching ink painting, with a specific percentage of 73.6%, however, about a quarter of the teachers still gave feedback on the existence of technical difficulties in operation. Among the student population, digital teaching tools aroused a clear interest with a support rate of 85.2%, and they generally agreed that this format could stimulate learning and enhance artistic expression. Regarding the design of teaching content, teachers suggested specific improvements, with particular emphasis on enhancing the interactivity of digital resources as well as enhancing the realism of the simulation of Chinese painting strokes. In the survey of different teaching modes, compared with the innovation of content and evaluation methods, teachers' attitude towards promoting teacher-student interaction through digital technology was particularly positive, with a score of 4.07, indicating that interactive innovation has become an important breakthrough in digital teaching. In addition, the factor of teaching age has a significant impact on the application of digital technology, with novice teachers and senior teachers showing relatively low levels of technology adaptation. The questionnaire survey not only lays a solid foundation for the subsequent optimization of teaching strategies and the development of teacher training programs, but also reveals the obstacles and directions of progress in the current reform of digital teaching and learning, which requires continuous attention to the supporting guarantee of technology training and resource development.

III. C. Experimental research method

In this study, a semester-long systematic experiment was conducted in two parallel classes in the freshman year of art education program in a higher education institution, which is of great significance in exploring the practical effects of graphological algorithms in the children's ink painting course in higher education. Through careful selection, we divided 42 students into an experimental group to be taught by digital-based teaching methods, and the other 45 students as a control group to follow the traditional teaching mode. Under the premise of ensuring the scientific validity and reliability of the experiment, we balanced the background factors of the two groups, such as gender composition, knowledge reserve and artistic literacy, and ensured that the teaching experience and professional level of the instructors were basically the same. The experimental group used our self-developed

digital teaching platform, which uses the core algorithm of graphics to accurately simulate the characteristics of ink painting strokes, and its basic transformation formula is:

$$T(x, y) = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix} \tag{1}$$

The parameters in the transformation matrix can realize the flexible regulation of the brushstroke form, the matrix elements control the rotation and scaling changes of the brushstroke, and the displacement component is responsible for regulating the positional changes of the brushstroke, so as to realistically restore the strength level of the brushstroke and the ink halo effect of the ink painting.

This study establishes a multi-dimensional assessment system to examine the learning effect from multiple perspectives, such as mastery of technique, creative interest and expressive ability, and specific evaluation indexes are set for each dimension. The collection of assessment data covers a variety of forms, such as mid-term and final work assessment, process evaluation records and questionnaires, etc. Five experienced experts independently grade students' works according to the unified standards, and the average score is used as the basis for the assessment. In the experimental implementation stage, we strictly follow the requirements of the syllabus to ensure that the two groups have the same number of class hours and the teaching progress is unified. With the help of statistical analysis software to process the collected data, the independent sample test was used to compare the differences between the two groups in the performance of various indicators. By conducting in-depth interviews with some of the teachers and students, rich qualitative research information was obtained, which provided a powerful supplementary explanation for the quantitative analysis. The experimental group made full use of the intelligent assessment system to analyze and feedback students' works in real time during the course, helping students to find problems and correct them in time, and the standardized control of the whole experimental process ensured that the research results were highly scientific and persuasive.

Combined with the systematic course evaluation system and quantitative calculation method, we explored the far-reaching impact of the algorithmic technology of graphics on the teaching effect of ink painting. After repeated demonstration and validation, we constructed a set of scientific assessment formulas to measure the overall learning performance of students, which can be expressed as:

$$E = \frac{\sum_{i=1}^{n} S_i}{n} \tag{2}$$

The formula E represents the teaching effectiveness assessment score, S_i represents the comprehensive score of the i th student, n is the total number of participating students, and the scoring dimensions cover a wide range of dimensions from basic techniques to innovative thinking.

III. D. Interview method

In this study, the effectiveness of the application of digital teaching tools was explored in depth. 12 ink painting course teachers and 32 school students were selected as interview subjects, and primary data were collected through face-to-face in-depth conversations. During the in-depth conversations with the teachers, many interviewees fully affirmed the unique advantages of graphology algorithms in simulating ink painting strokes. Of particular note, a veteran teacher who has been teaching for fifteen years shared her teaching experience with us, "The digital tools make it easier for students to understand and master the basic brush strokes, especially in the demonstration teaching sessions, where zoomed-in demonstrations and real-time interactive features make teaching lively and interesting." However, at the level of technology application, some teachers also told us about the difficulties they encountered in the process of using the tools, and hoped to receive more professional training and technical support. The student body has shown great enthusiasm for this innovative teaching method, and they generally believe that the digital platform provides a safe place for experimentation in artistic creation. As one freshman said in an interview, "Practicing ink painting through the digital platform allows me to boldly experiment with different expressive techniques without worrying about wasting rice paper and paint."

Based on the feedback from teachers and students, we found that digital teaching tools need to fully utilize the technological advantages while maintaining the artistic essence of ink painting, and it is especially important to strengthen the teacher training system. Students also made suggestions for improvement, including the development of a mobile application to facilitate after-class practice and the enhancement of the naturalness of human-computer interaction, which are valuable suggestions that point the way for subsequent optimization of the teaching tools and improvement of the digital teaching system. Through in-depth analysis of the interview data, we

not only gained first-hand information on the current status of teaching tools, but also found a breakthrough for further improvement of the digital teaching platform.

IV. Findings and analysis

IV. A. Analysis of experimental results

In this study, through a semester-long actual teaching experiment, the teaching effect of children's ink painting course was tested for the experimental and control group students, and its specific results were obtained as shown in Table 2.

Table 2: Comparison of teaching effects between experimental and control group

Evaluation dimension	Experimental group	Control group	Increase amplitude
Mastery of basic techniques	86.5	78.3	10.5%
Degree of creative interest	92.3	75.6	22.1%
Expressiveness of the work	88.7	79.2	12.0%
Innovative thinking	90.2	76.8	17.4%
Comprehensive score	89.4	77.5	15.4%

An in-depth analysis of the teaching practices behind the data reveals that the digital teaching method supported by the graphical algorithms demonstrated significant advantages in multiple dimensions. Students in the experimental group achieved an average score of 86.5 points in basic technique mastery, a 10.5 percentage point increase compared to the control group, which is attributed to the clear brushstroke demonstration and instant feedback mechanism provided by the digital tool. In terms of creative interest, the experimental group outperformed the control group by 22.1 percentage points with a score of 92.3, which fully reflects the positive effect of the interactivity and fun of the digital teaching platform on stimulating learning enthusiasm. What is more noteworthy is that the experimental students showed a significant improvement of 17.4% in the dimension of innovative thinking compared with the control class. Through in-depth observation of the students' works, we found that the works of the experimental group showed stronger personalized characteristics in terms of composition and layout, ink levels and expression of mood. This increase in creativity is attributed to the diversified creative tools and rich art material library provided by the digital platform, which enables students to break through the traditional limitations and gain greater creative freedom in the process of artistic exploration.

IV. B. Analysis of interview results

Data from interviews with 12 teachers and 32 students showed that the digital teaching tools achieved good teaching results in the children's ink drawing course for senior teachers. Teachers generally reflected that the graphic algorithms improved the quality of classroom teaching, especially the intelligent evaluation function was very helpful for teaching management. A teacher talked about, "The digital platform can analyze the direction of students' strokes, helping me to discover the problems of each student in time, and classroom teaching is more targeted." Some teachers put forward some suggestions for improvement. For example, the teacher hoped to add a stylized analysis function for Chinese paintings, believing that this would help students better understand the artistic context of traditional ink paintings. In addition to teachers' feedback, students also generally agreed that the digital teaching platform is helpful in increasing learning interest, mastering techniques, improving creative efficiency and cultivating artistic perception. A freshman said, "I used to practice ink drawing always worried about breaking the paper, but multiple attempts on the digital platform instead helped me master the techniques better."

In the process of organizing the interview data, we found that digital teaching tools do play an important role in improving teaching efficiency and stimulating learning interest. Both teachers and students made specific optimization suggestions for the platform, such as enhancing the strength feedback of brush strokes, improving the color halo effect, and other features. These comments reflect that there is still a lot of room for the development of graphic algorithms in the teaching of ink painting techniques, especially in the two aspects of brushstroke simulation and stylized expression, which need to be further improved. Through this interview and survey, we not only saw the actual value of digital teaching innovation, but also found a specific direction to improve the platform. At present, it seems that the key to making digital teaching tools better serve the children's ink painting courses for senior teachers is to continue to optimize them at the technical level, so that they can be more in line with the actual needs of teaching.

V. Conclusion

Based on the graphology algorithm, it is applied to the digital teaching of children's ink painting course in high school teachers, and its purpose is to further enhance the digital teaching effect of children's ink painting course in high school teachers. This paper analyzes the feasibility of the graphology algorithm in the digital teaching of children's ink painting course for senior teachers through literature research, questionnaire survey, experimental research and interviews, respectively. The study shows that after the digital teaching of children's ink painting course in high teachers combined with graphology algorithms, the experimental class appears to be significantly improved in the dimensions of basic technique mastery, creative interest degree, innovative thinking, and comprehensive score. Combined with the results of the post-class interviews, the feasibility of the application of graphology algorithms in the digital teaching of children's ink and wash painting course for high school teachers is fully lifespan, which provides a new exploratory path for the digital reform and teaching quality improvement of children's ink and wash painting course for high school teachers.

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